SCARAB:

ABSOLUTE CALIBRATION & INTER-COMPARISON WITH CERES

MEGHA-TROPIQUES MISSION

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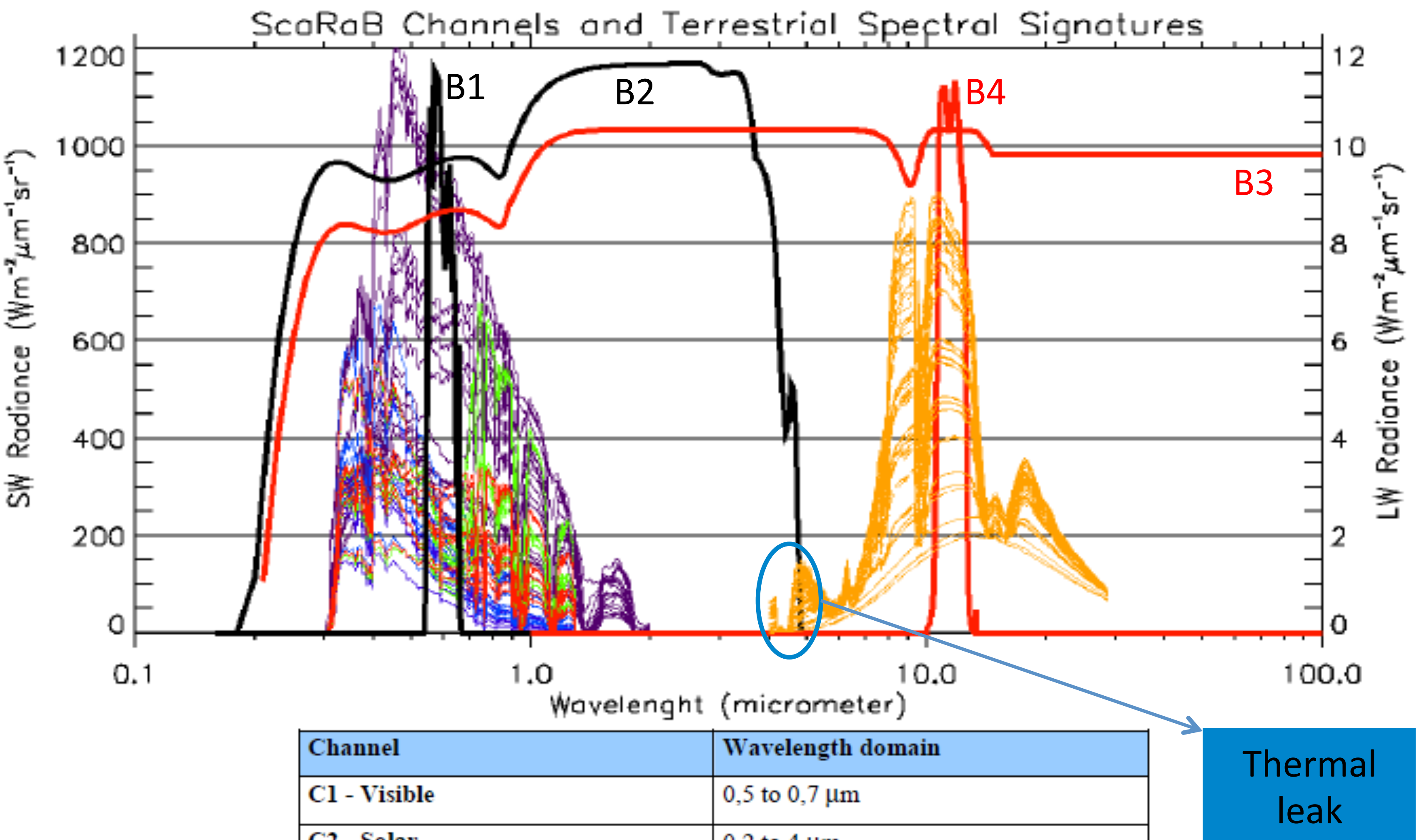
MEGHA-TROPIQUES MISSION

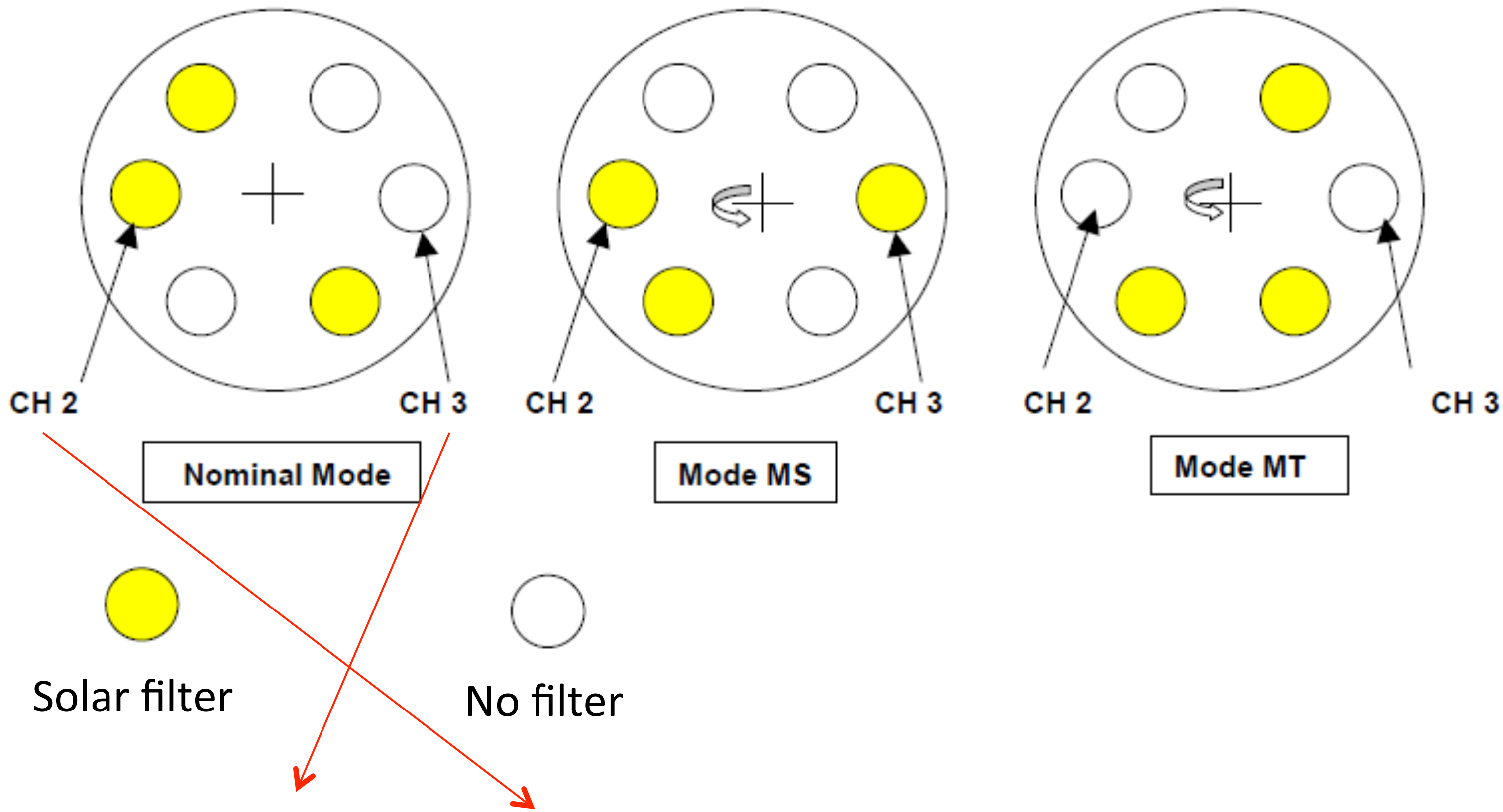
Mission	Study of the atmosphere in the intertropical zone
Launch date	12 October 2011
Partners	CNES, ISRO
Instruments	MADRAS, SAPHIR, SCARAB
Localisation	Equatorial orbit (inclined 20°) at an altitude of 867 km
Mission lifetime	3 years, extended a further 2 years

SCARAB SPECTRAL BANDS



Channel	Wavelength domain
C1 - Visible	0,5 to 0,7 µm
C2 - Solar	0,2 to 4 µm
C3 - Total	0,2 to 200 µm
C4 - IR Window	10 to 13 µm

SCARAB ACQUISITION MODES



$$L_{lw} = L_{tot} - A^{'} . L_{sw}$$

Basic equations :

$$N_k = G_k L_k^f$$

$$\text{Where } L_k^f = \int L(\lambda) r_k(\lambda) d\lambda$$

Only filtered radiances are recorded (filtered by all the channel : mirror, filter, ...)

When N_k and G_k are known, L^f_k is deduced

When N_k and L^f_k are known, G_k is deduced

►**principle of the calibration**

Determination of A' :

A' is used to subtract the SW component of the signal acquired on channel-3. This SW component is measured on channel-2, similar to channel-3 but not fully identical:

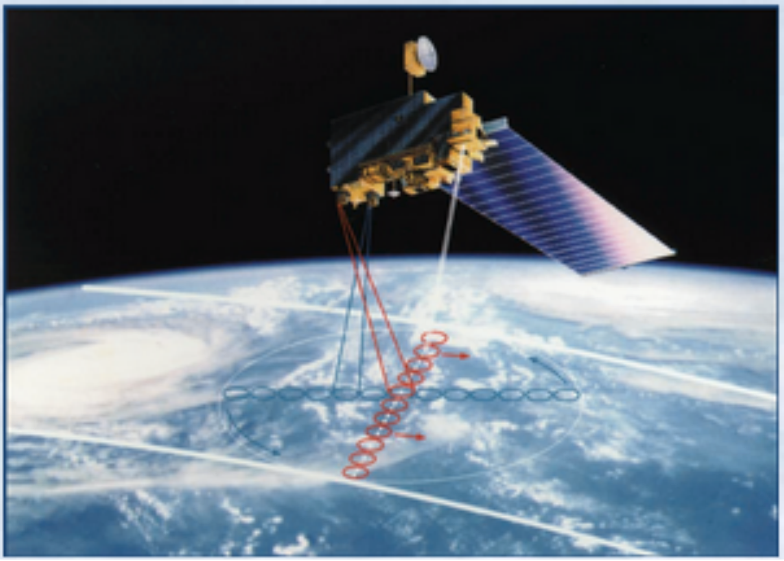
$$\mathbf{L_{lw}^{f} = L_{T}^{f} - A'\, L_{sw}^{f}}$$

A' can be expressed as the ratio between Ch3 and Ch2 pointing at a « pure » SW source:

$$\mathbf{A' = \int L_{sw}(\lambda)\, r_3(\lambda)\, d\lambda \,/\, \int L_{sw}(\lambda)\, r_2(\lambda)\, d\lambda}$$

QUICK REVIEW OF CERES

THE CERES (FM2) INSTRUMENT ONBOARD TERRA



Orbits	705 km altitude, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (PM-1), sun-synchronous, near-polar; 350 km altitude, 35° inclination (TRMM)
Spectral Channels	Solar Reflected Radiation (Shortwave): 0.3 - 5.0 µm Window: 8 - 12 µm Total: 0.3 to > 100 µm
Swath Dimensions	Limb to limb
Angular Sampling	Cross-track scan and 360° azimuth biaxial scan
Spatial Resolution	20 km at nadir (10 km for TRMM)
Mass	45 kg
Duty Cycle	100%
Power	45 W
Data Rate	10 kbps
Size	60 x 60 x 70 cm (deployed)
Design Life	6 years

INTER-SENSOR COMPARISON: FIRST APPROACH

INTRODUCTION – ERROR BUDGET

ScaRaB-SW error budget @ 1σ ≈ 1,6%

Items	Value	Type	
Short wave calibration (sphere)	3% @2σ	Biais	1.5%
Error on spectral response		Biais	0.4%
Thermal gain correction	0.08%/°	Random	0.03%
	dT= 0.04° @1σ		
Thermal leak correction	20% of the thermal leak@1σ	Random	0.04%
Location	0.06°@1σ	Random	0.4%
Budget at 1 sigma			1.6%

Rosak et al., 2012

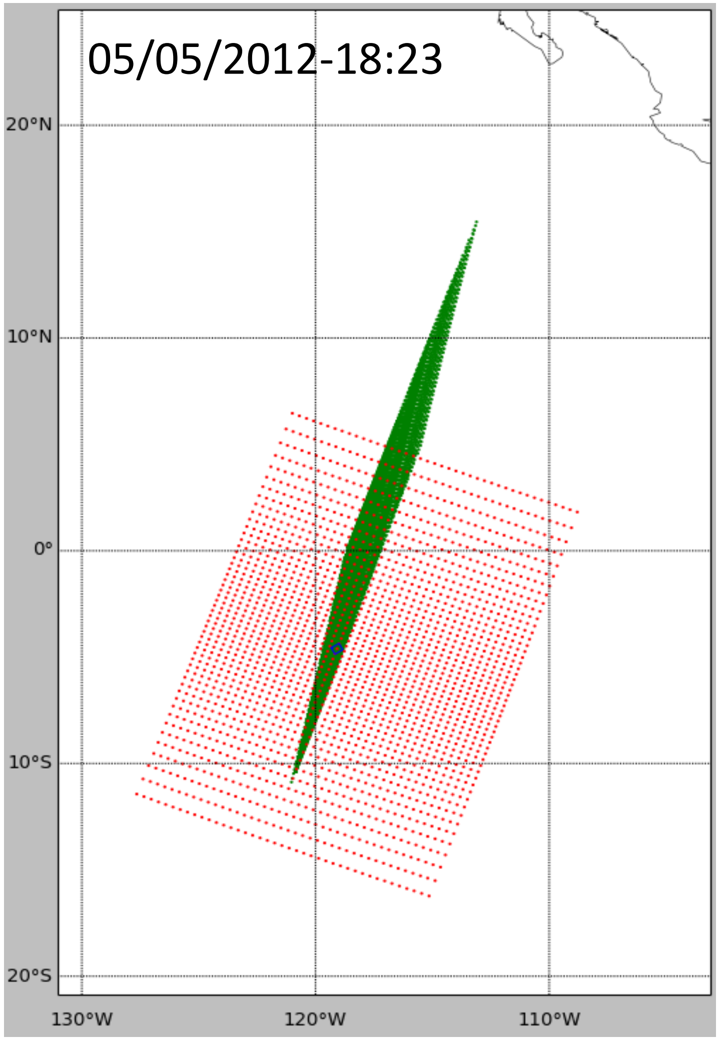
CERES-FM2-SW error budget @ 1σ ≈ 1%

	Bias errors of unknown sign ($W\ m^{-2}$)				
Source	Incoming solar	Outgoing SW	Outgoing LW	Net incoming	Comment
Total solar irradiance	±0.2	0	0	±0.2	Absolute calibration (95% confidence)
Filtered radiance	0	±2.0	±2.4 (N) ±5.0 (D)	±4.2	Absolute calibration (95% confidence)
Unfiltered radiance	0	±0.5	±0.25 (N) ±0.45 (D)	±1.0	- Instrument spectral response function - Unfiltering algorithm

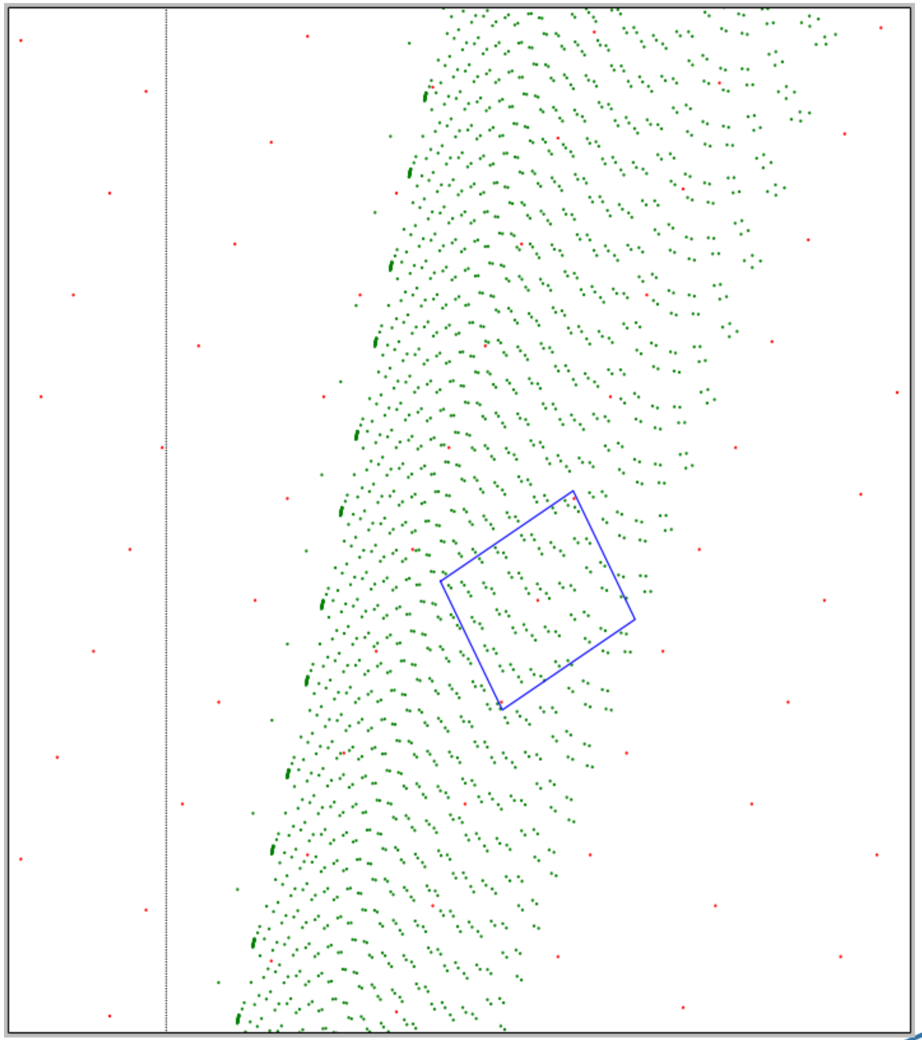
Loeb et al., 2009 [CERES-FM2 error budget @2σ]

They showed that their error budget was consistent with the climate monitoring.

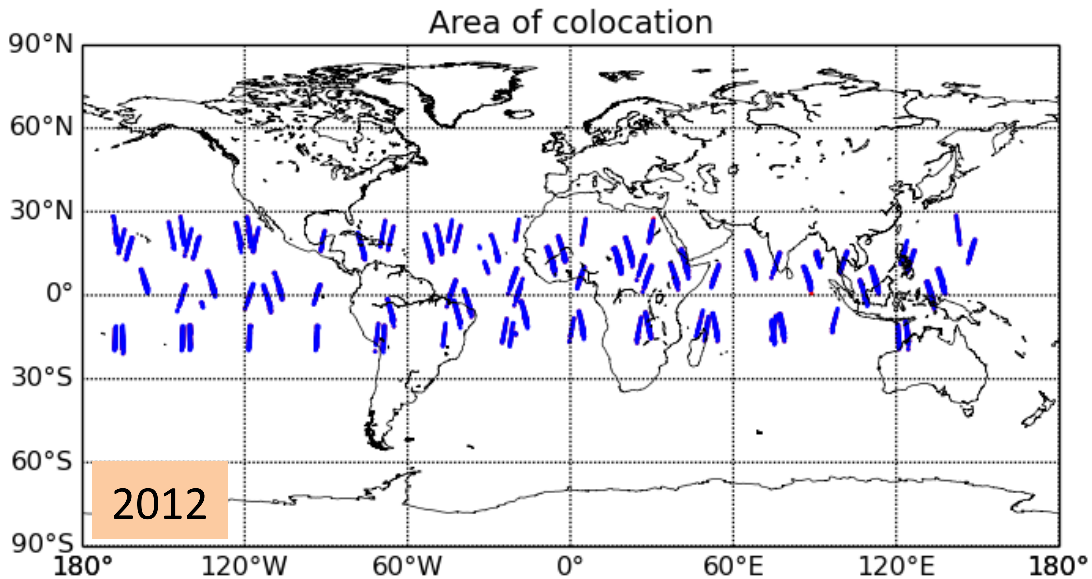
CERES PIXELS IN SCARAB GEOMETRY

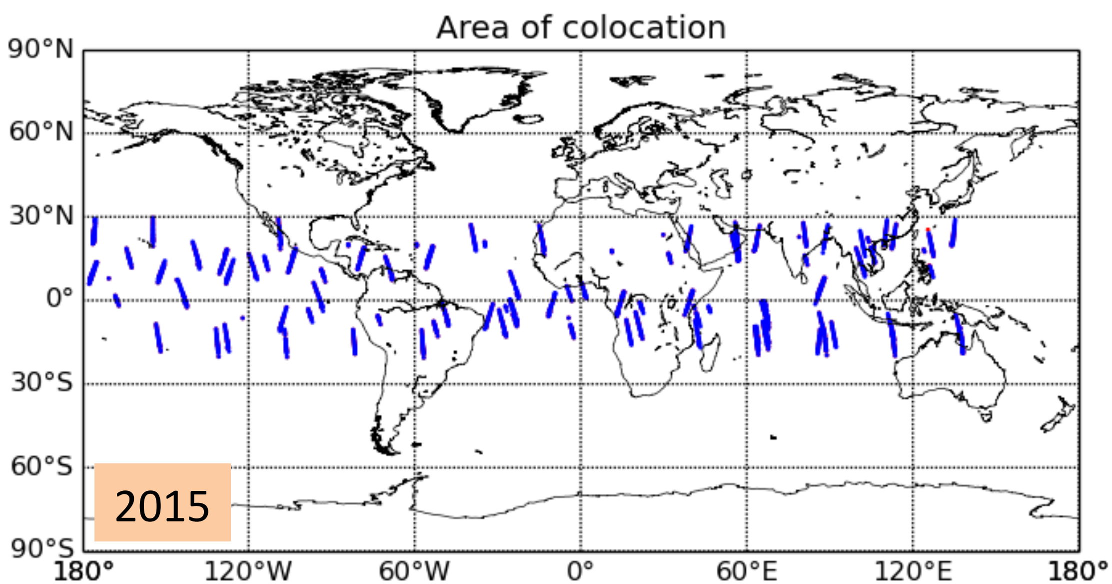


Zooming



CO-LOCATION AREA





INTER-SENSOR COMPARISON: SUCCESSIVE APPROACHES

GENERAL STATEMENT

Any time a CERES-ScaRaB pixels comparison is performed, the criterion is :

We use the following metric in our results =>

$$\frac{ScaRaB - CERES}{mean(CERES)} \text{ (in \%)}$$

FIRST APPROACH

The average of CERES pixels of which the center is located in a ScaRaB foot-print is compared to this ScaRaB pixel.

Advantage :

- A huge number of pixels are considered.

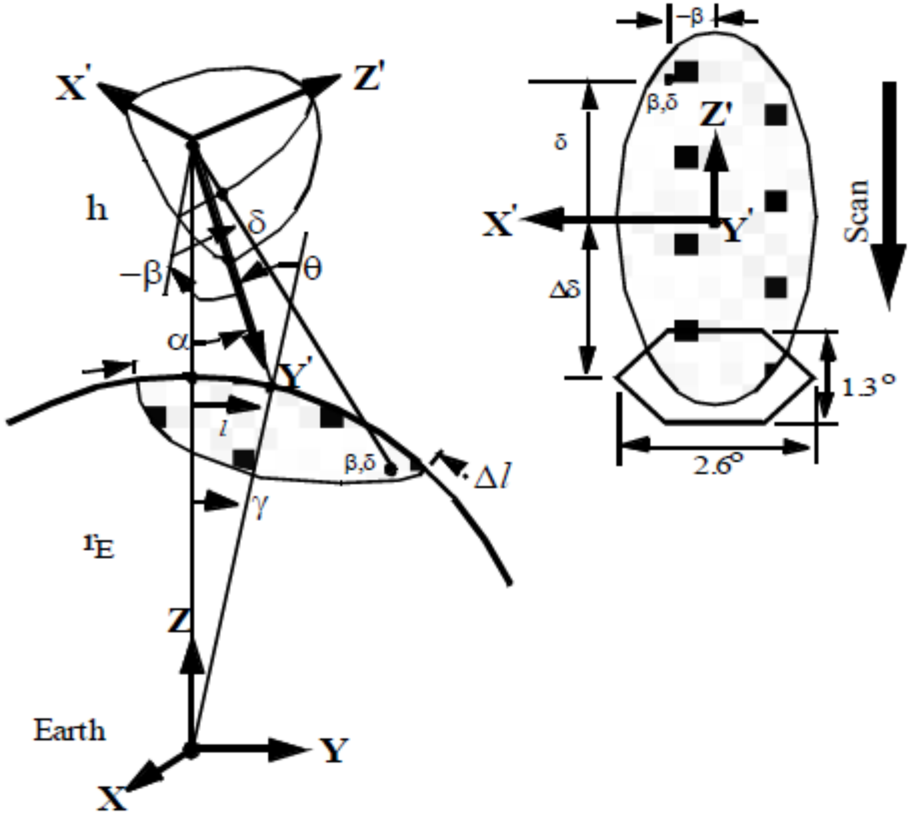
Drawbacks :

- The shape of CERES pixel is ignored.
- CERES pixels can widely overflow the ScaRaB pixel.

SECOND AND THIRD APPROACHES

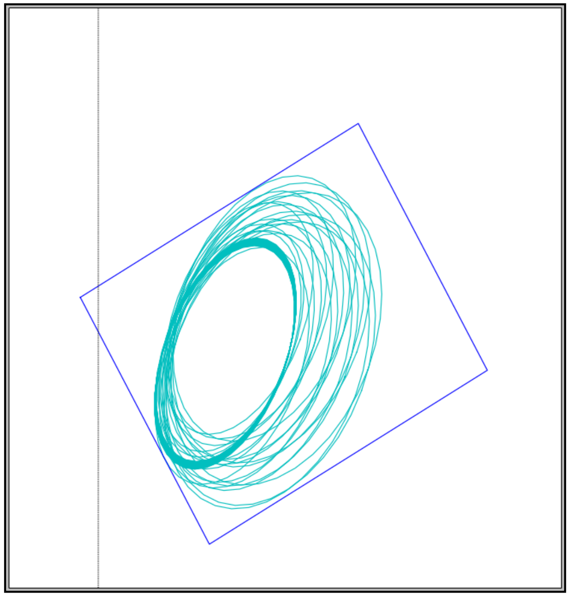
CERES REAL FOOTPRINT

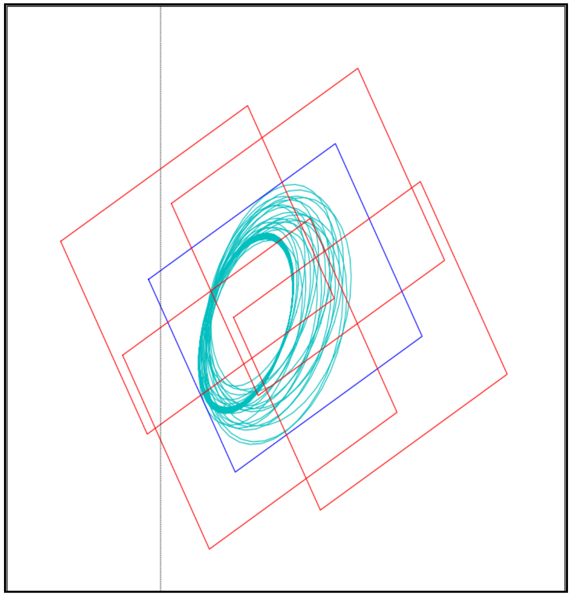
In our first colocation approach we considered a **circular** CERES *footprint* with a **20 km** diameter (at Nadir). It was a good approximation. In order to improve our results, we need to consider the real CERES *footprint*.



Scanner Footprint

IMPROVEMENT OF THE CO-LOCATION METHOD

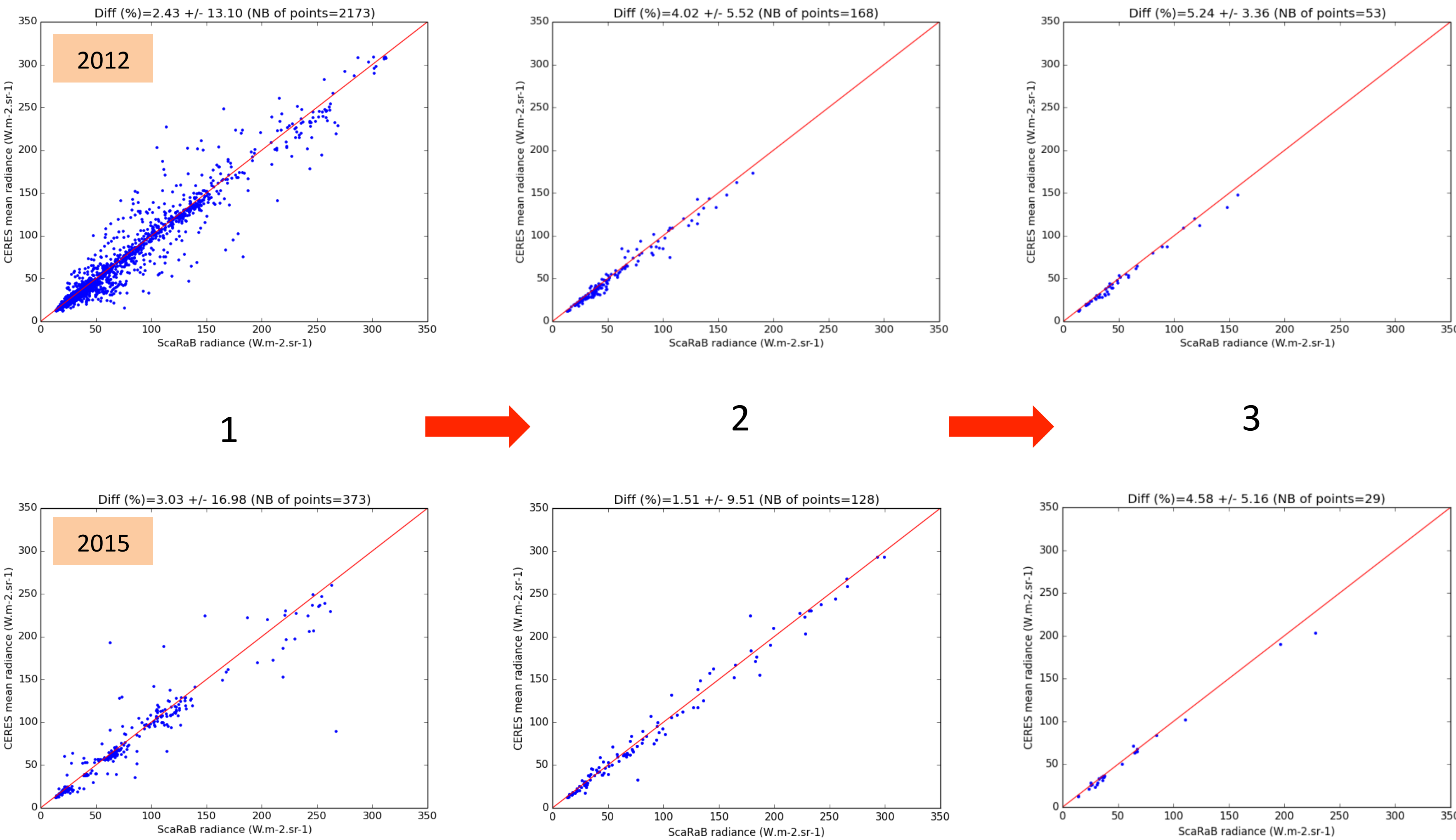




To improve our colocation method, we considered three kinds of improvements :

1. We consider the **real** CERES *footprint* (left caption).
2. The **entire** CERES footprint (cyan) must be contained in the ScaRaB footprint (left caption).
3. We **only** considered ScaRaB pixels which present radiometric homogeneity (right caption) – neighbors heterogeneity (red) is lower than 10 %.

SECOND APPROACH: RESULTS FOR SW



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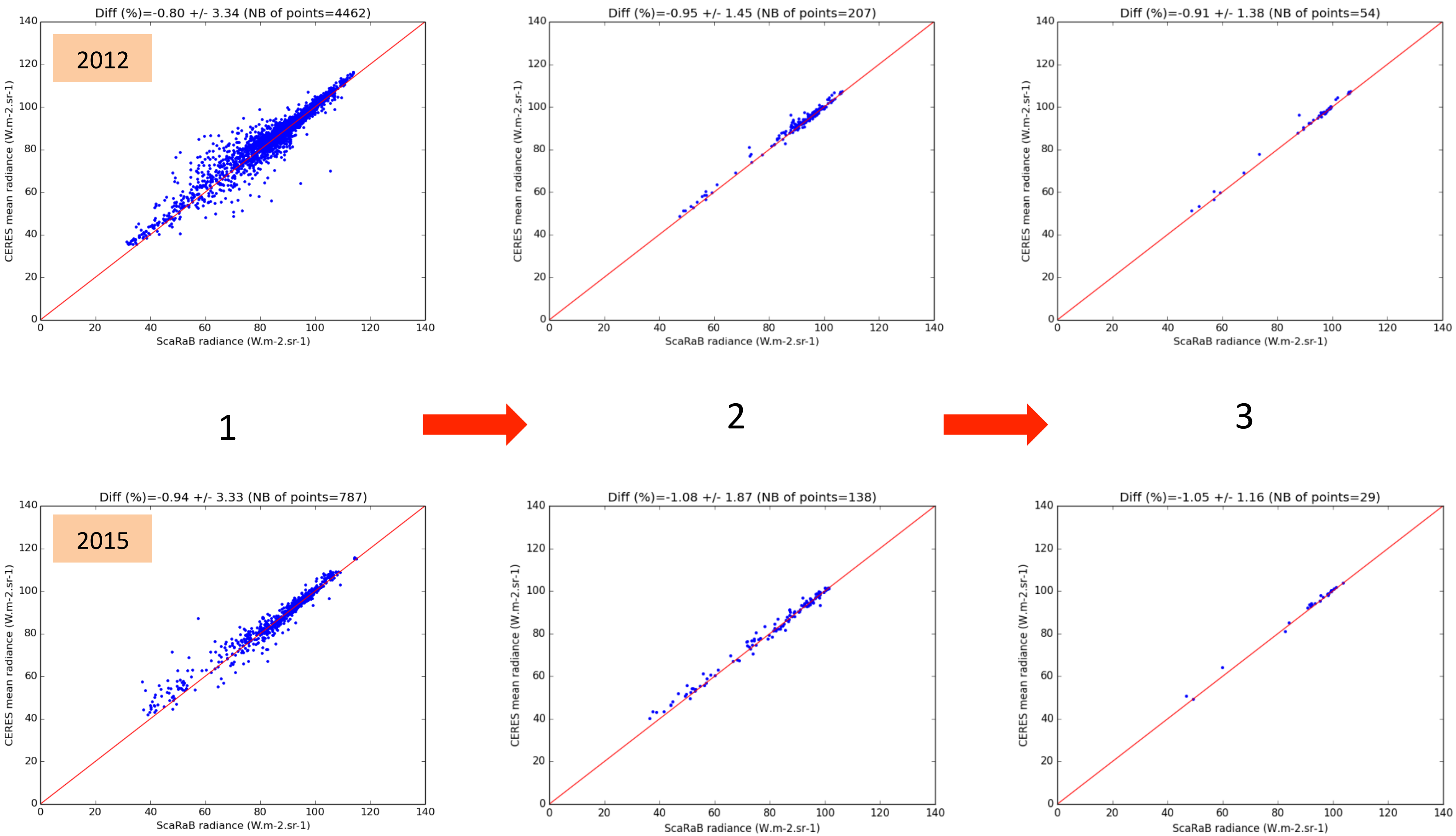
SECOND APPROACH: RESULTS FOR LW



SUMMARY OF THE RESULTS

2012

Footprint		Circle	Ellipsis (1+2)	Homogeneous ellipsis (1+2+3)
ΔL (%)	SW	**2.43** ± 13.1 (2173)	**4.02** ± 5.52 (168)	**5.24** ± 3.36 (53)
	LW	**-0.8** ± 3.34 (4462)	**-0.95** ± 1.45 (207)	**-0.91** ± 1.38 (54)

2015

Footprint		Circle	Ellipsis (1+2)	Homogeneous ellipsis (1+2+3)
ΔL (%)	SW	**3.03** ± 17.0 (373)	**1.51** ± 9.51 (128)	**4.58** ± 5.16 (29)
	LW	**-0.94** ± 3.33 (787)	**-1.08** ± 1.87 (138)	**-1.05** ± 1.16 (29)

=> The different improvements have a benefit impact on the ScaRaB/CERES inter-comparison.
=> The improvement defined in case (1+2+3) present the best results (lowest dispersion).
=> The more the criteria are restrictive (1+2+3) the less we have colocation points.
=> We notice a deterioration of the results from 2012 and 2015 for SW (+1.14%) and for LW (+0.08%).

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CONCLUSION AND PERSPECTIVE

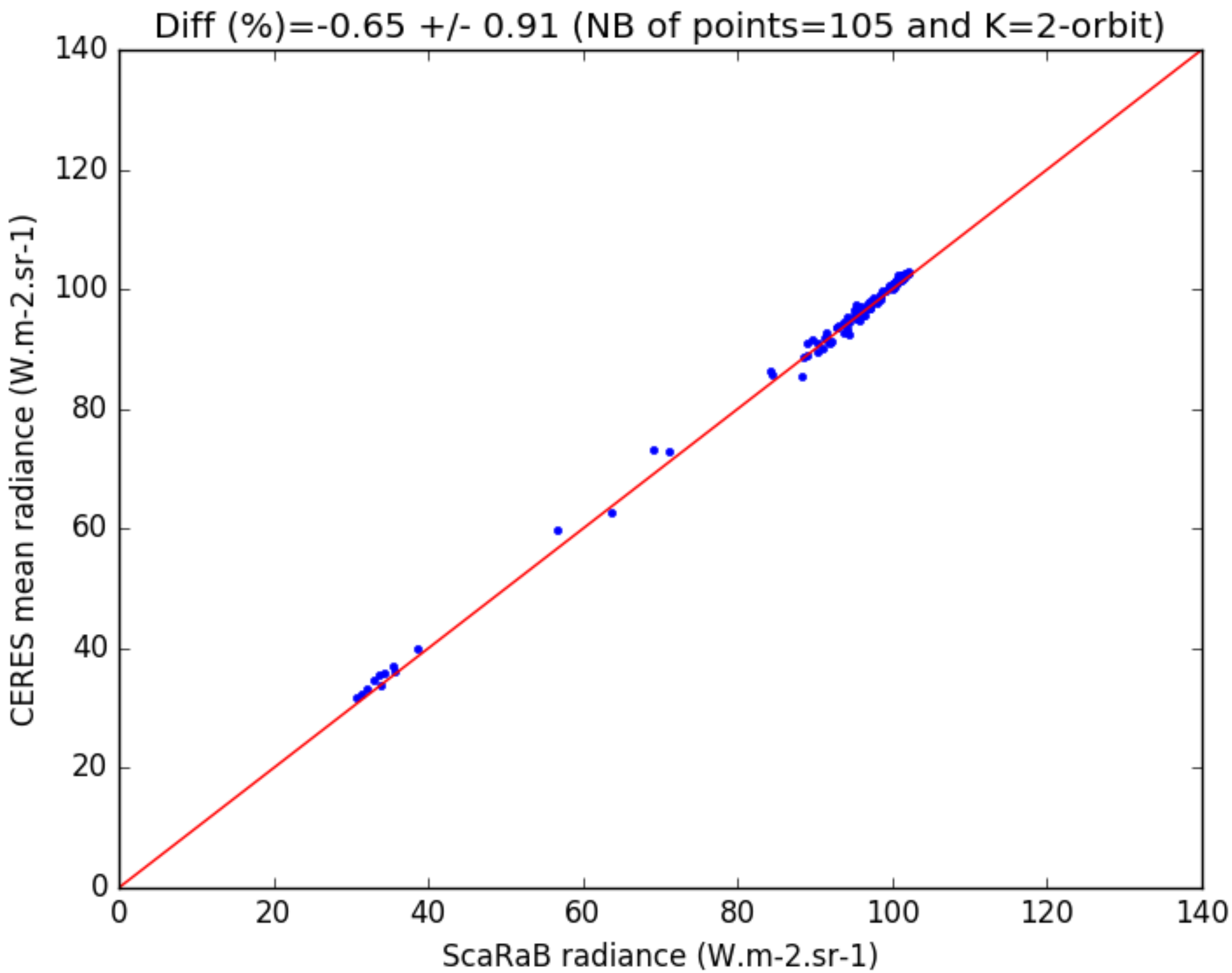
⇒ All the SCARAB radiometric parameters used to provide products are in accordance with specification.

⇒ The vicarious calibration of channel-1 (using desert sites) allows a monitoring with a precision of about 1.3%;

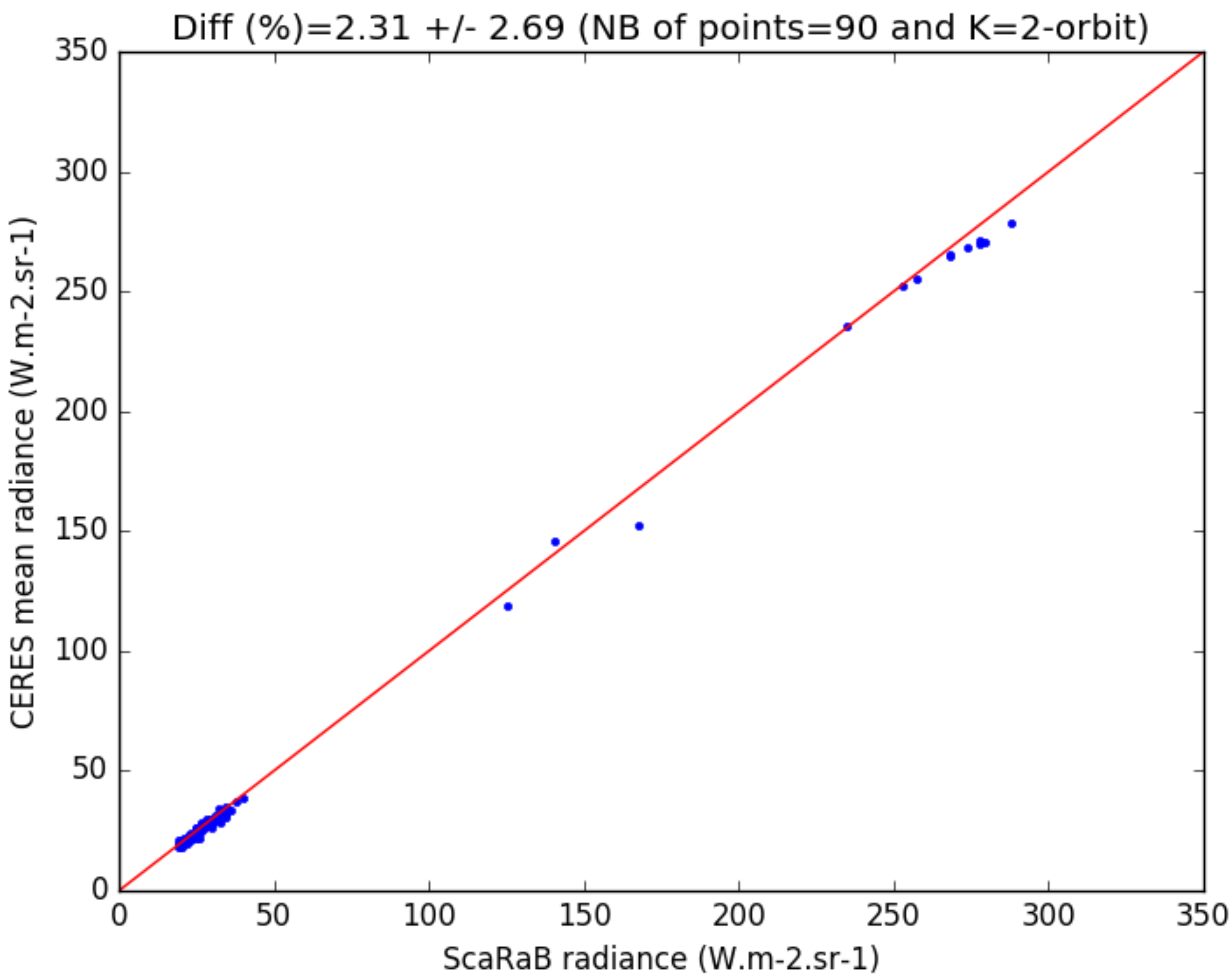
⇒ The inter-sensor calibration activity between CERES and SCARAB leads to the following results:

1. "good" agreement between two satellites: ≈ 5.0% in the SW and ≈ 1% in the LW.
2. Taking account of the real CERES *footprint* improves inter-sensor comparison results.
3. Best results are obtained using homogeneous ScaRaB pixel containing the entire real CERES footprint.
4. We notice a deterioration of the results from 2012 and 2015 for SW (+1.14%) and for LW (+0.08%).

LAST CAMPAIGN : UNCONSOLIDATED RESULTS FOR LW



LAST CAMPAIGN : UNCONSOLIDATED RESULTS FOR SW



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